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Nam et al.

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(54) **MOBILE X-RAY IMAGING APPARATUS**

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Related U.S. Application Data

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(51) **Int. Cl.**
A61B 6/10 (2006.01)
A61B 6/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 6/10*** (2013.01); ***A61B 6/00*** (2013.01); ***A61B 6/4405*** (2013.01); ***A61B 6/56*** (2013.01); *A61B 6/4266* (2013.01); *A61B 6/4283* (2013.01)

(58) **Field of Classification Search**
CPC A61B 6/10; A61B 6/00; A61B 6/4405; A61B 6/56; A61B 6/4266; A61B 6/4283
See application file for complete search history.

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Primary Examiner — Courtney D Thomas

(57) **ABSTRACT**

Disclosed herein is a mobile x-ray imaging apparatus having an improved structure to reinforce security of an x-ray detector. A mobile x-ray imaging apparatus includes an x-ray source configured to generate and radiate x-rays, one or more x-ray detectors provided to detect the x-rays radiated from the x-ray source, a storage unit having one or more slots in which the one or more x-ray detectors are stored, and one or more locking units installed in the storage unit to limit withdrawal of the one or more x-ray detectors stored in the one or more slots, wherein the one or more locking units may include a pressing member provided to be pressable and one or more rotating members configured to directly receive a pressing force of the pressing member and provided to rotate and protrude toward an inside of the one or more slots.

11 Claims, 15 Drawing Sheets

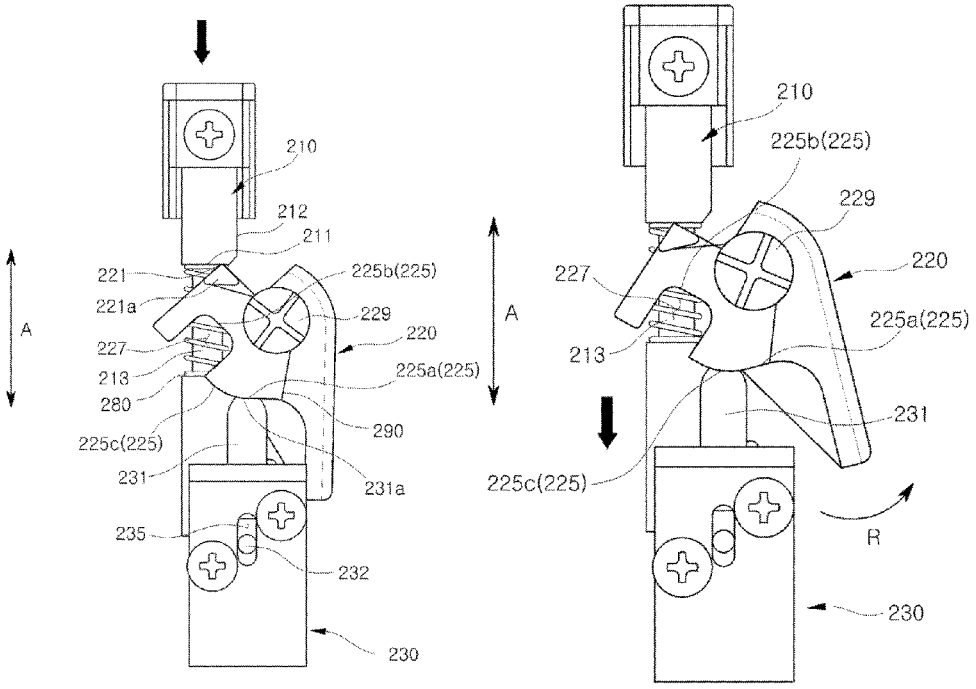


FIG. 1

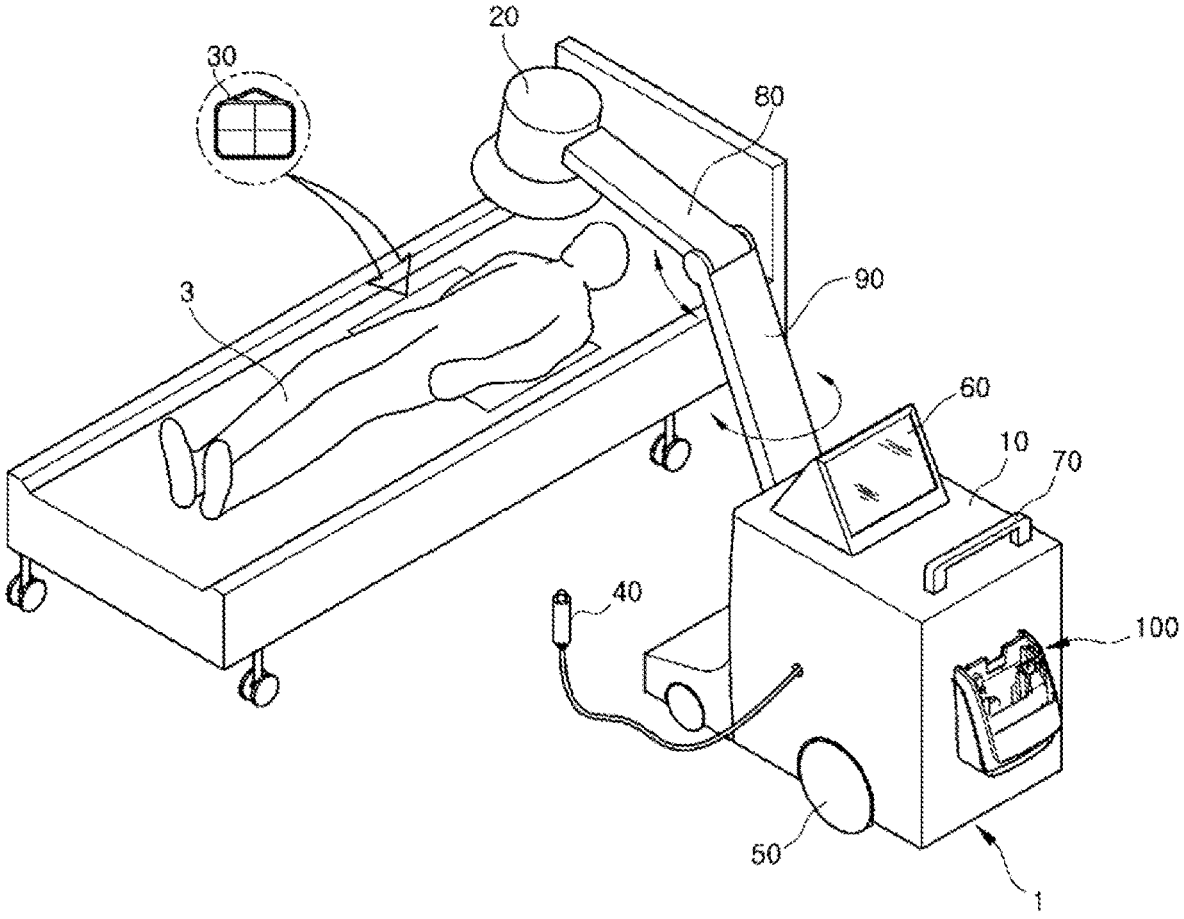


FIG. 2

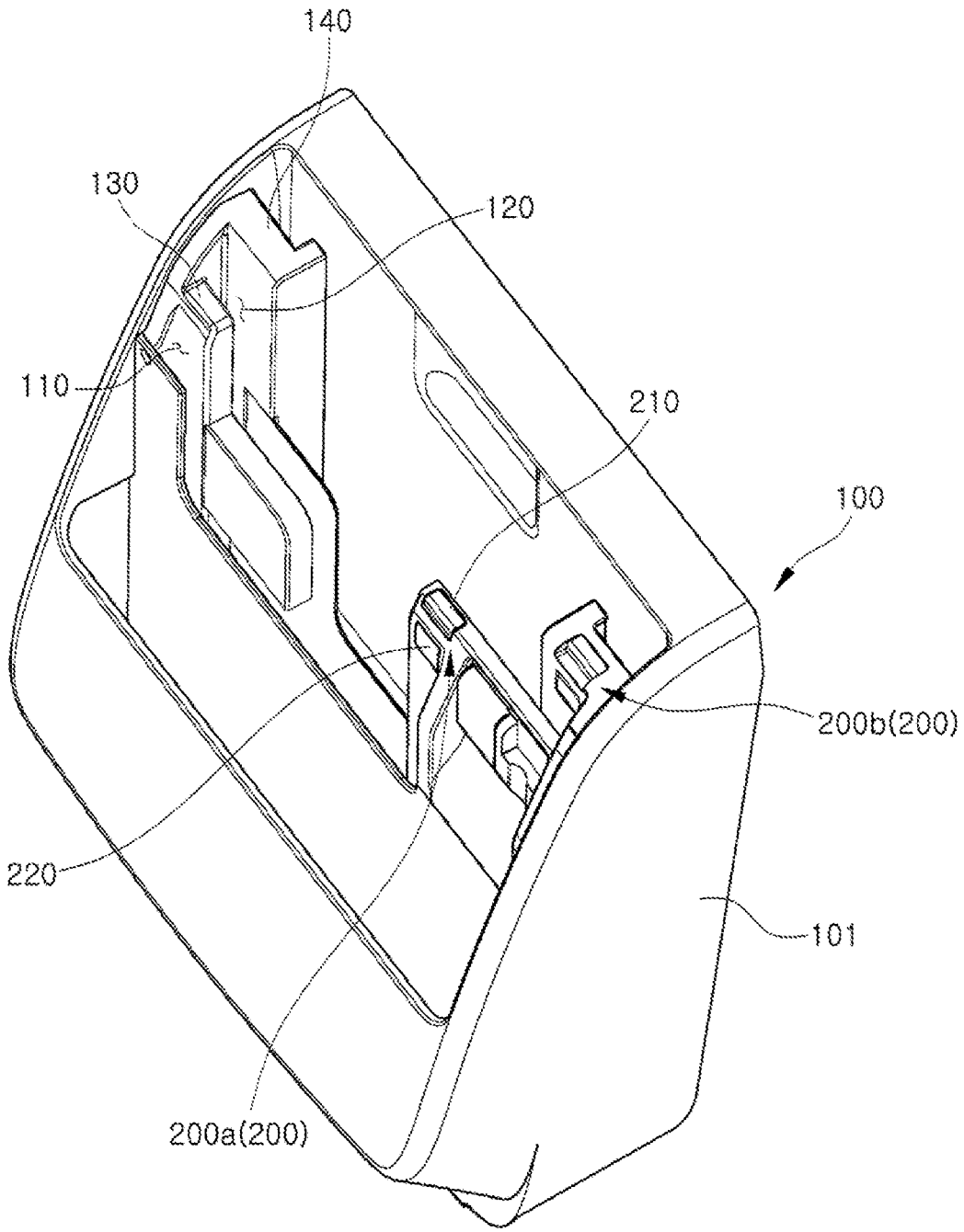
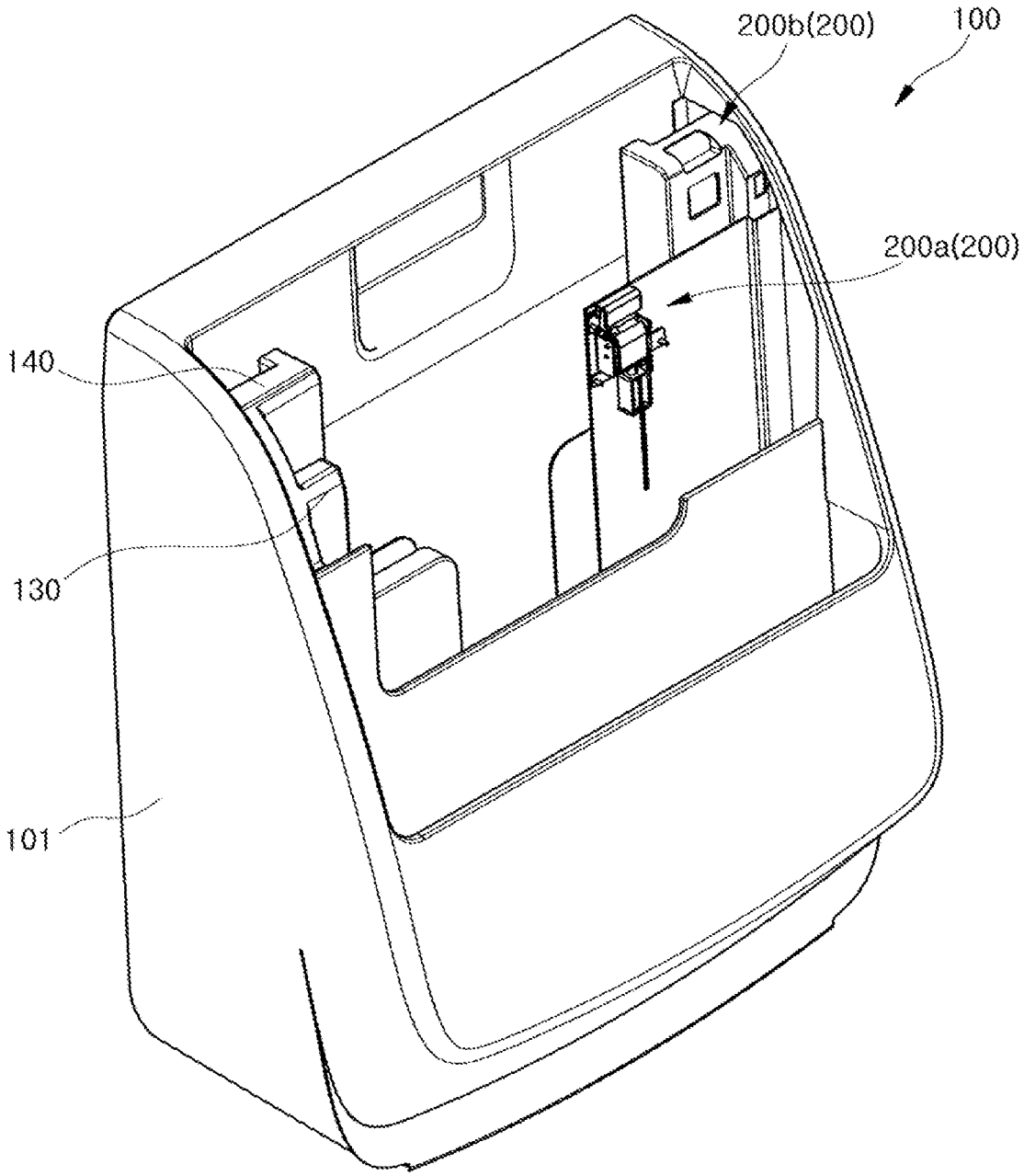


FIG. 3



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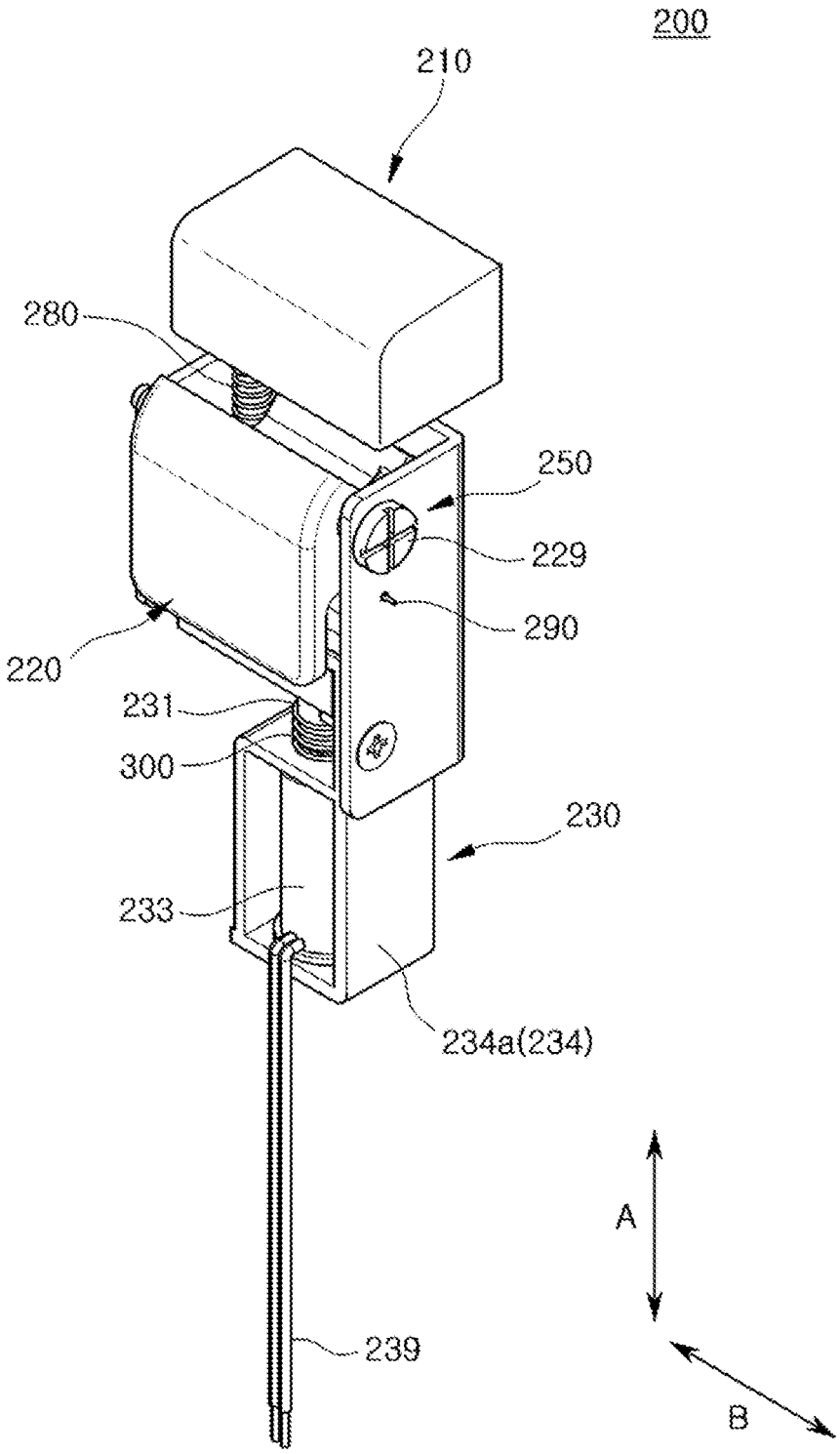

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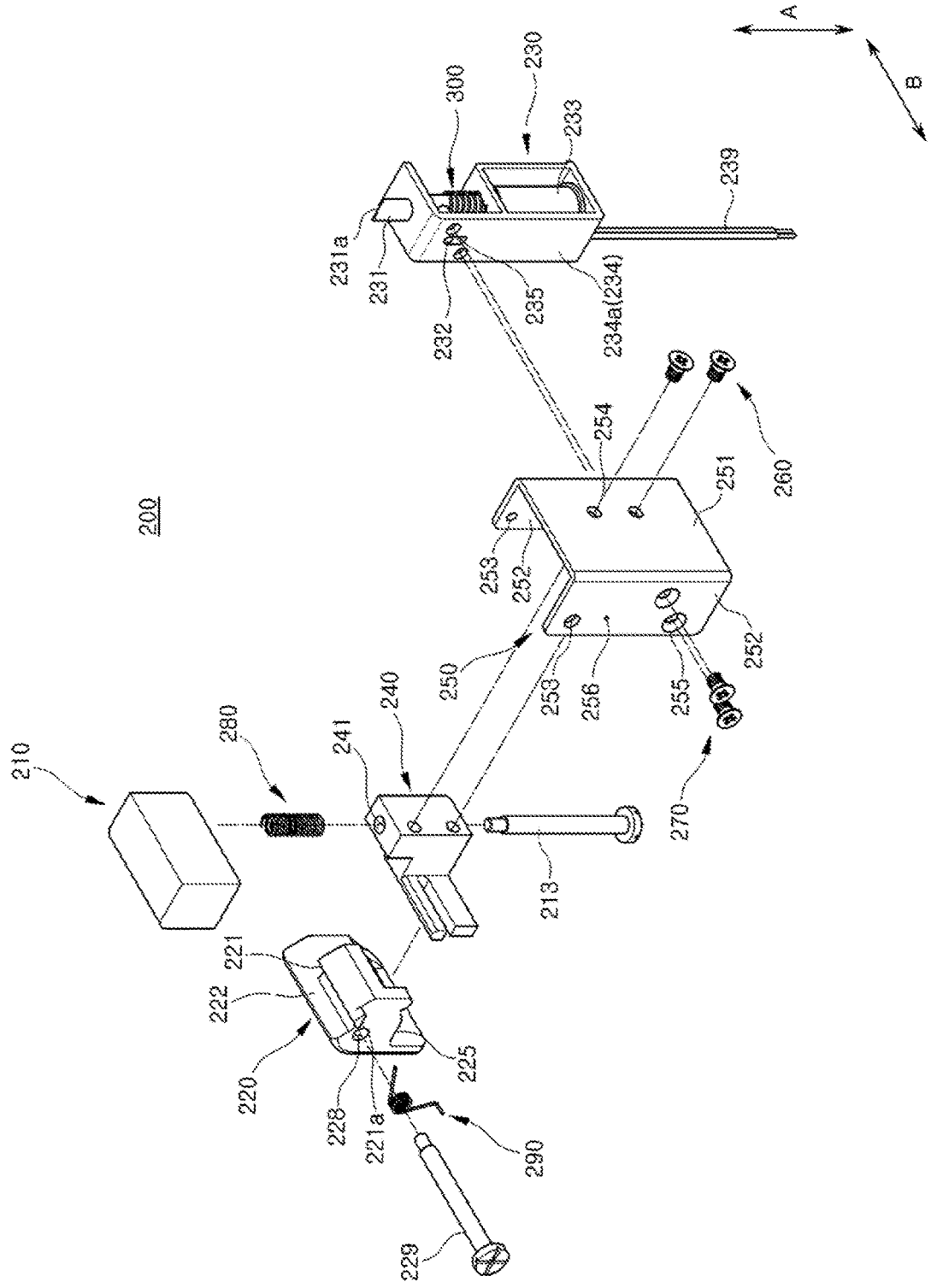
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FIG. 6A

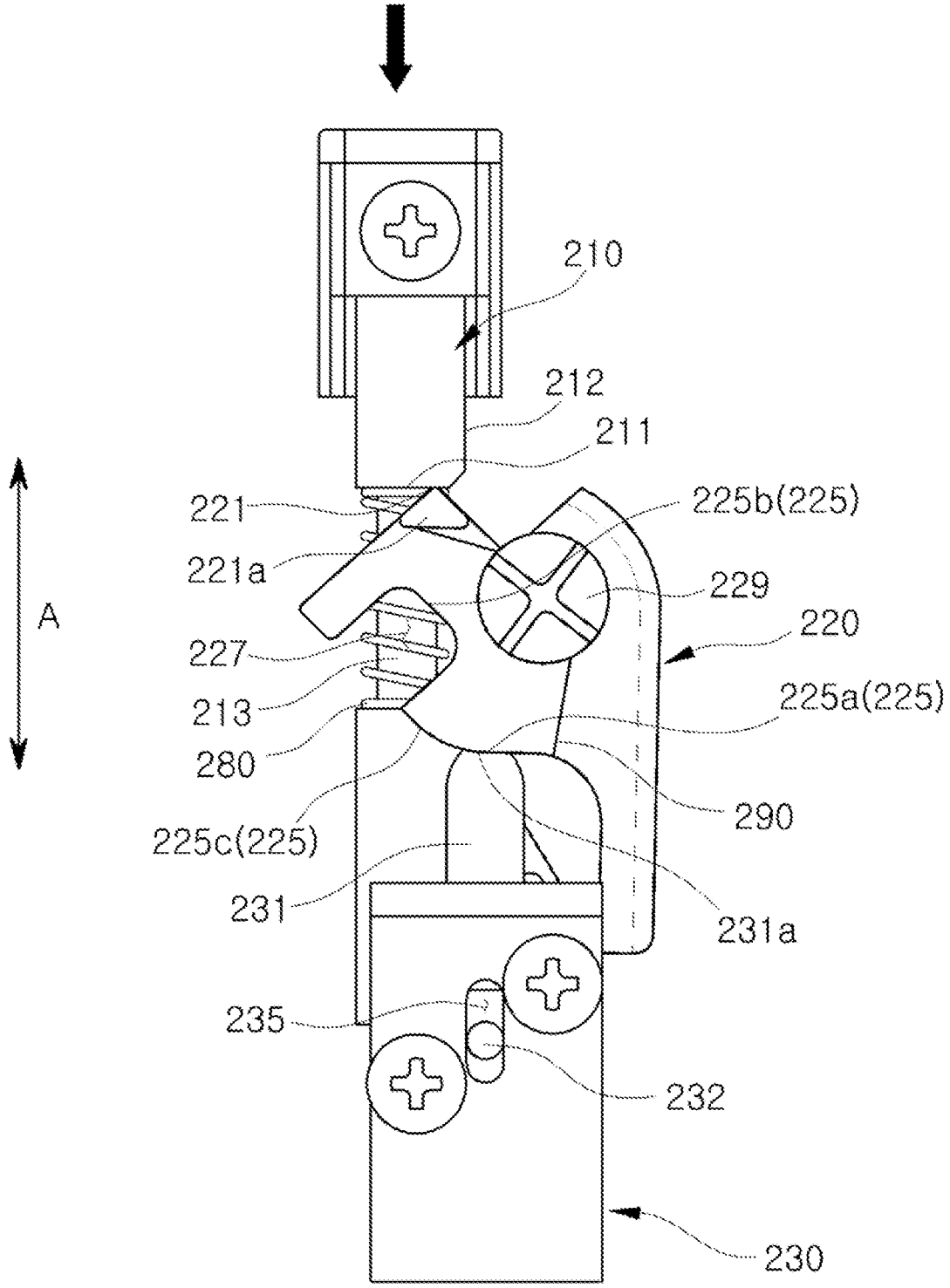
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FIG. 6B

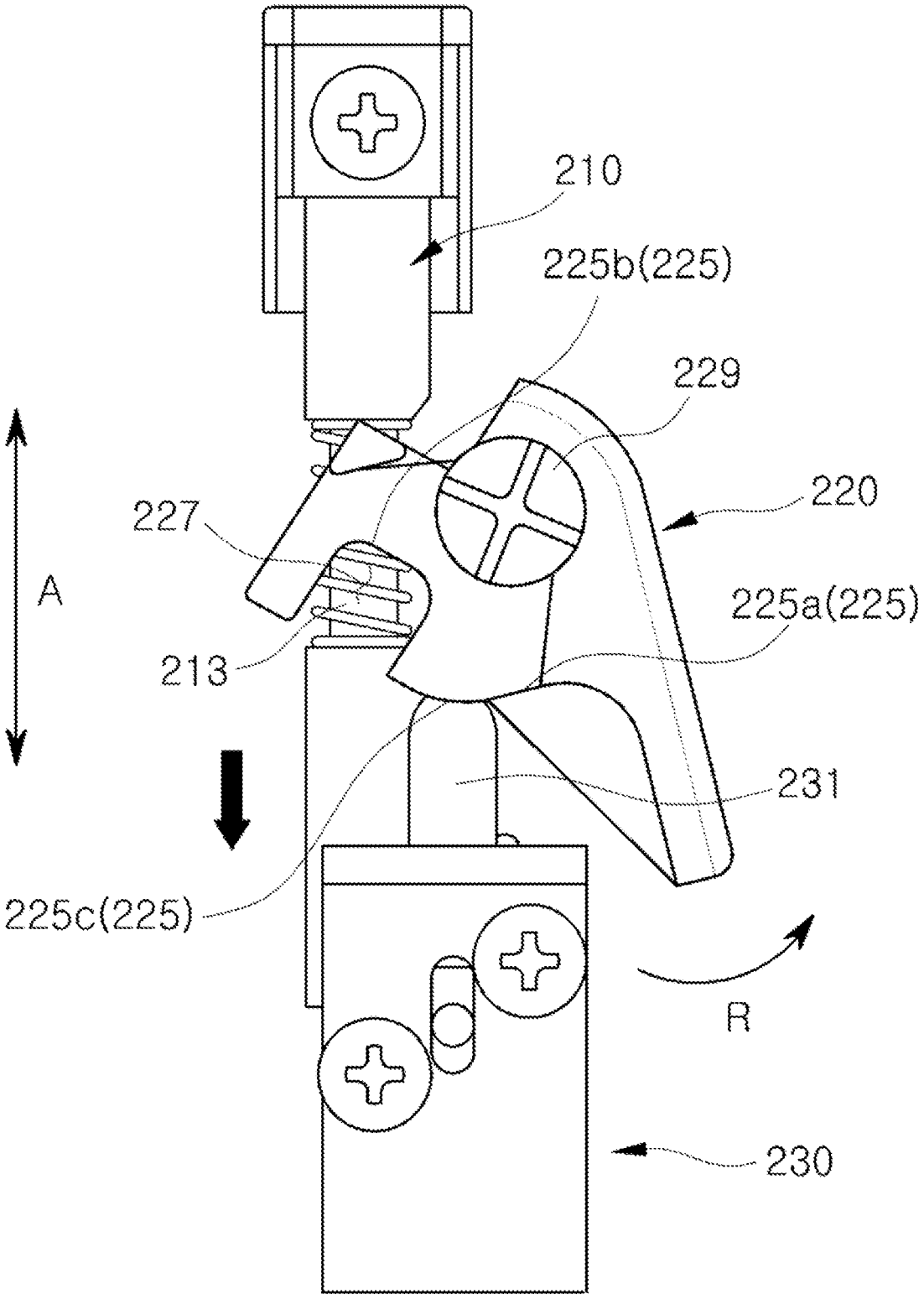

FIG. 6C

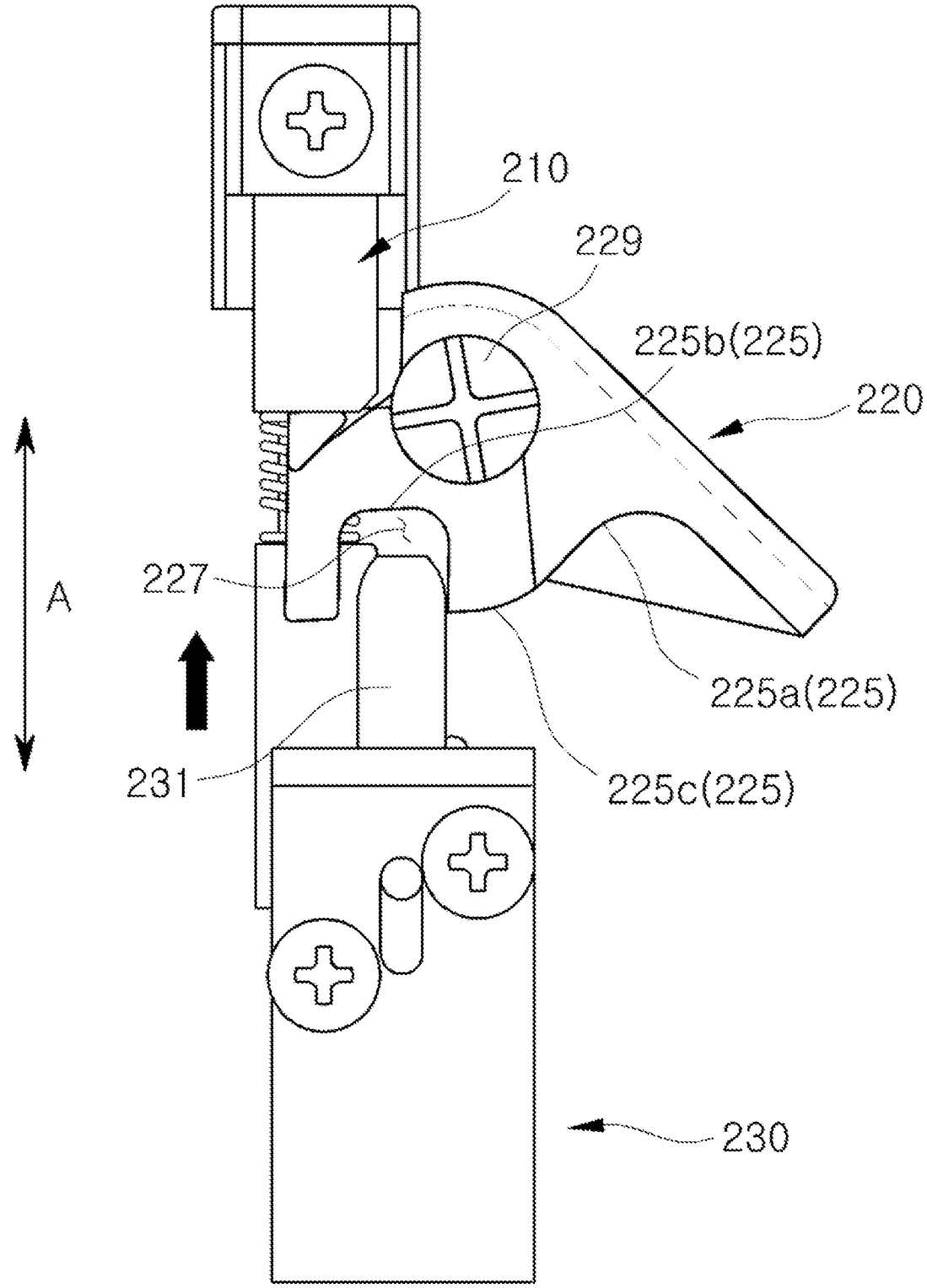

FIG. 7A

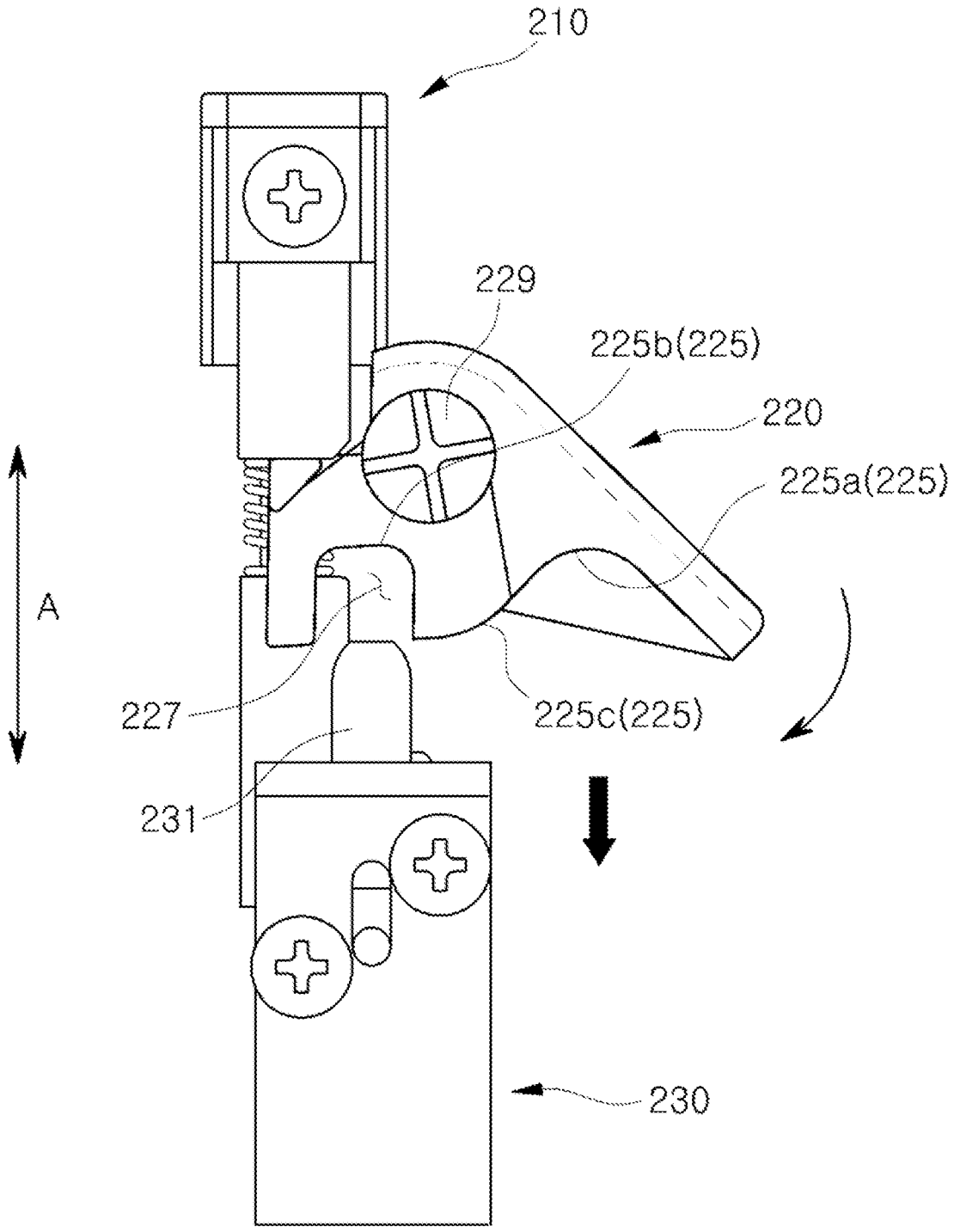

FIG. 7B

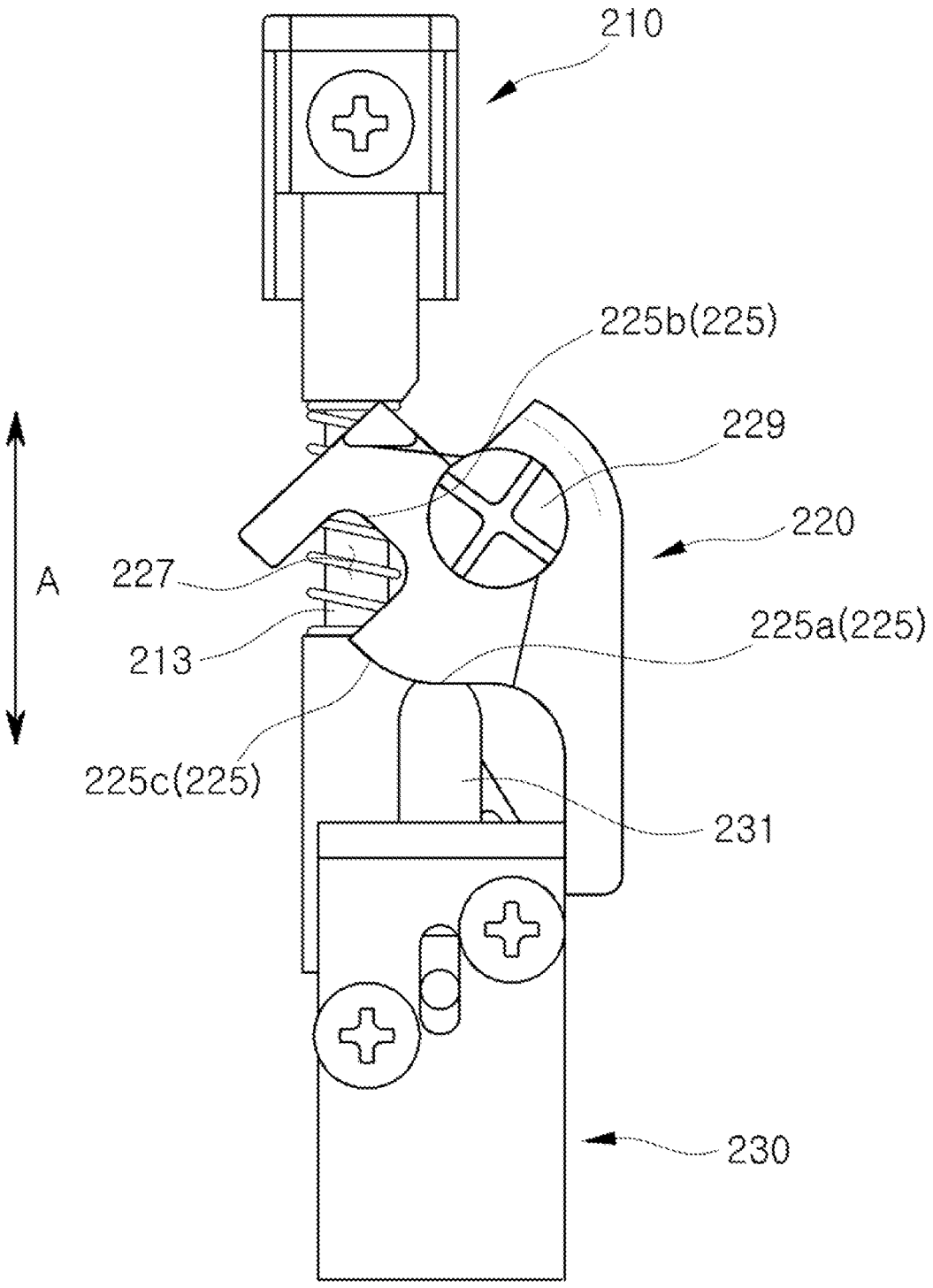

FIG. 8

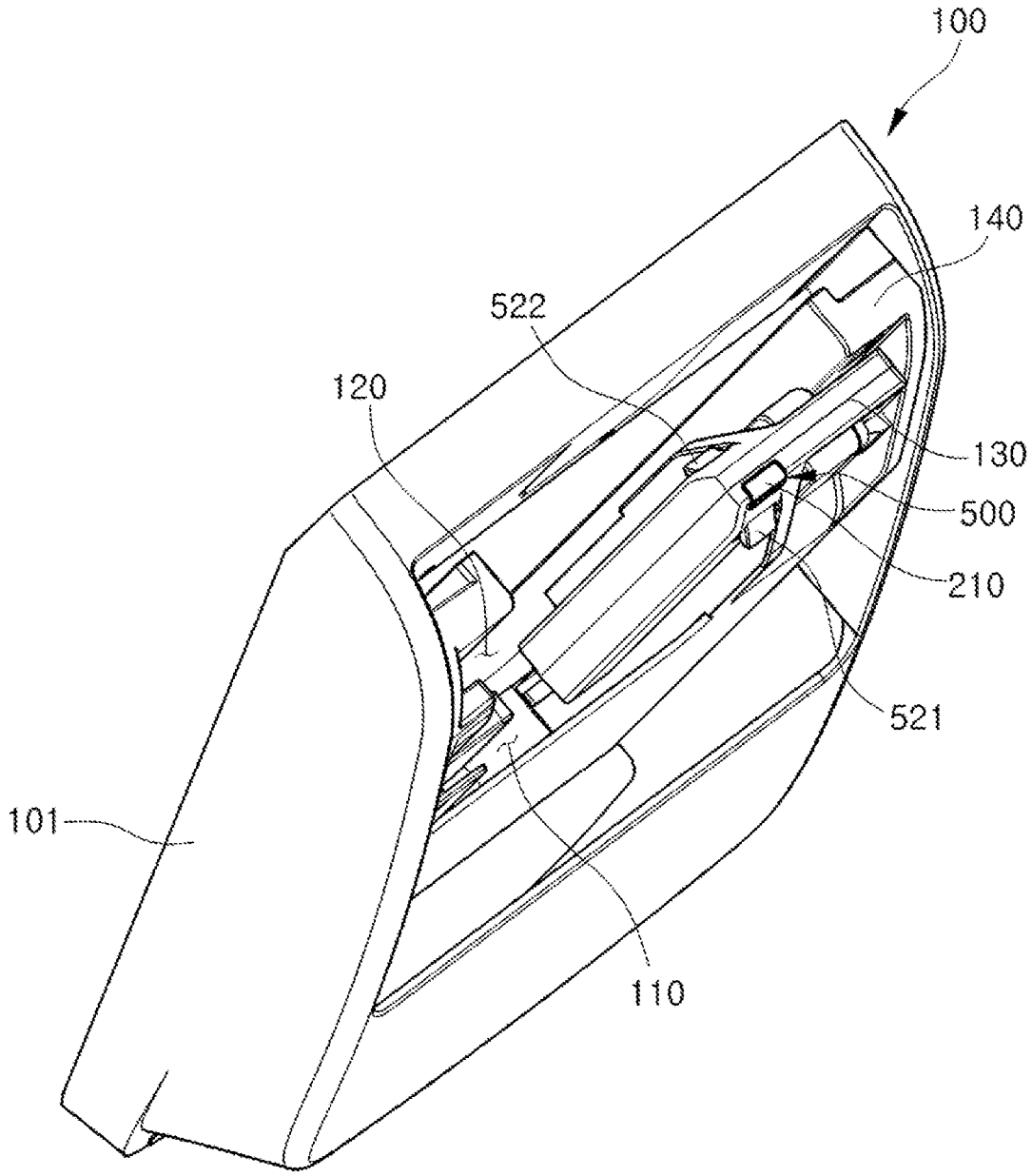

FIG. 9

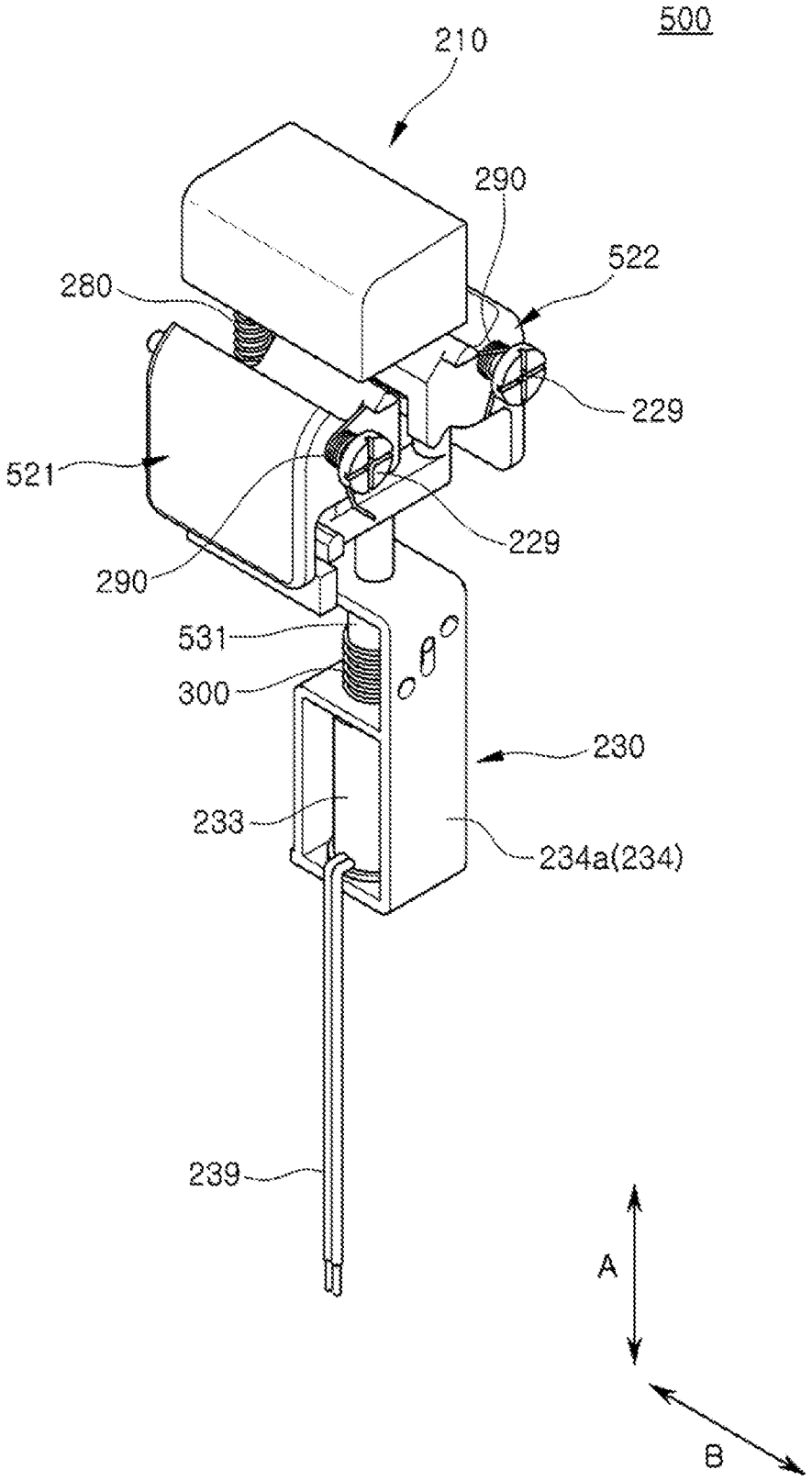
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FIG. 10

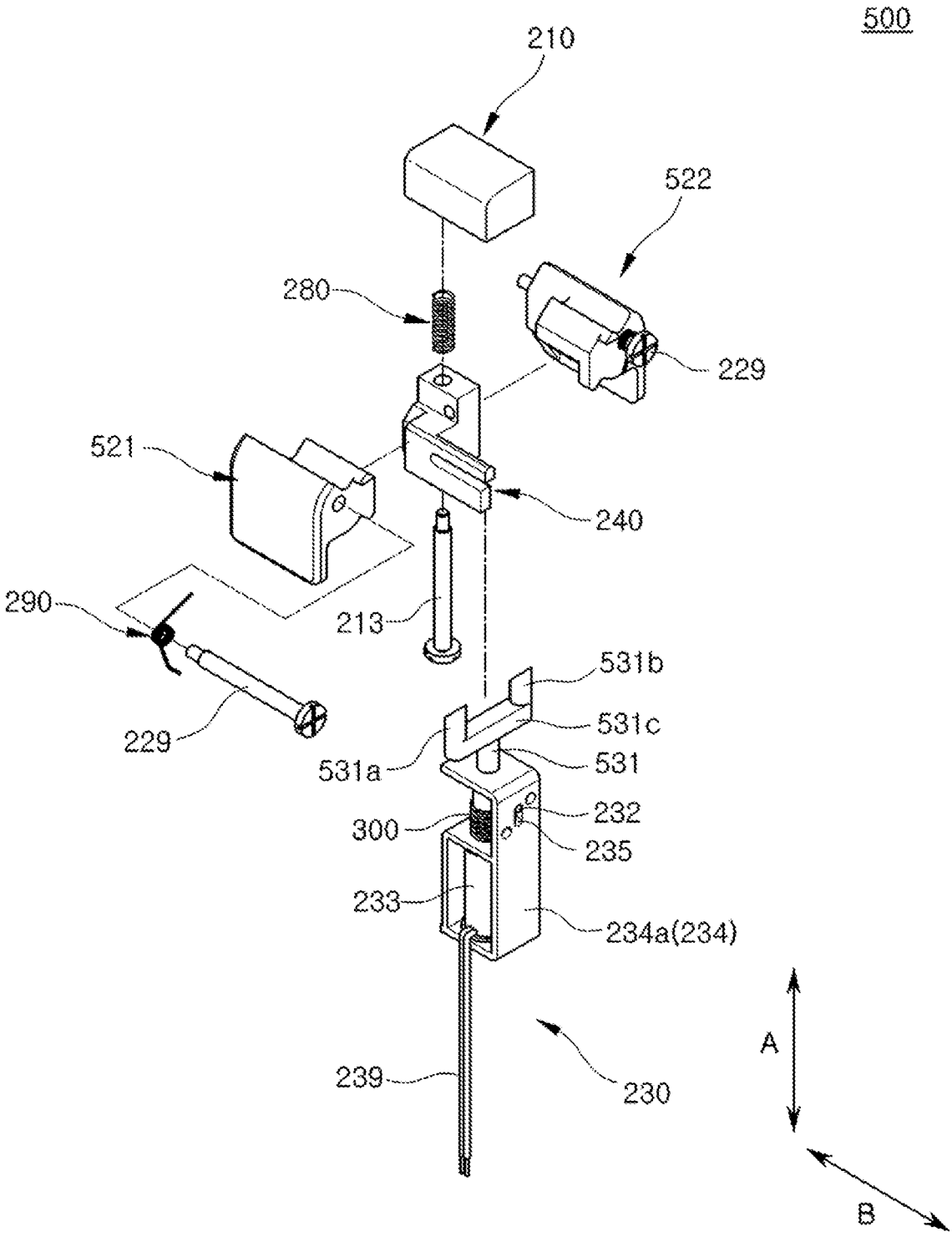
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FIG. 11

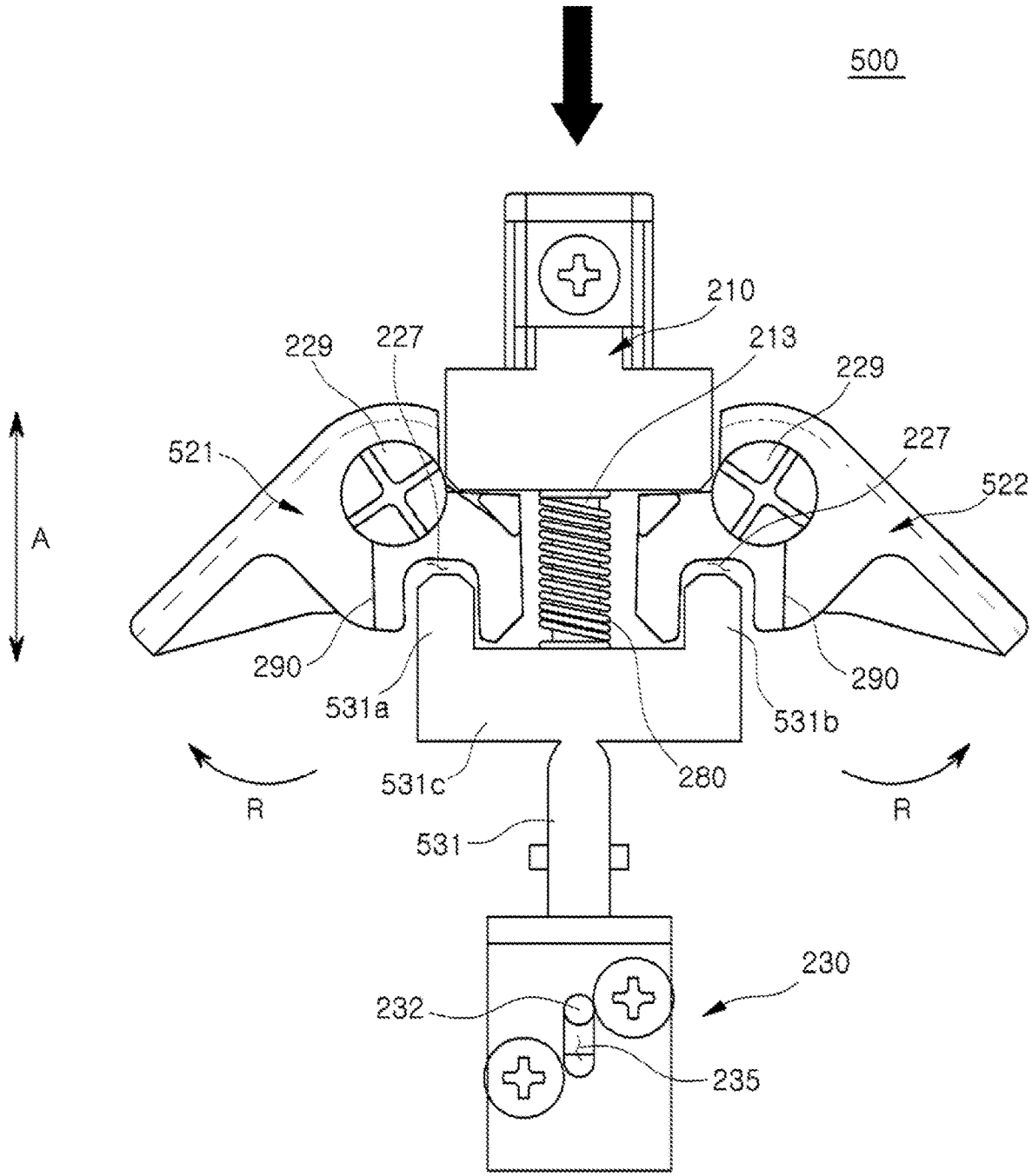
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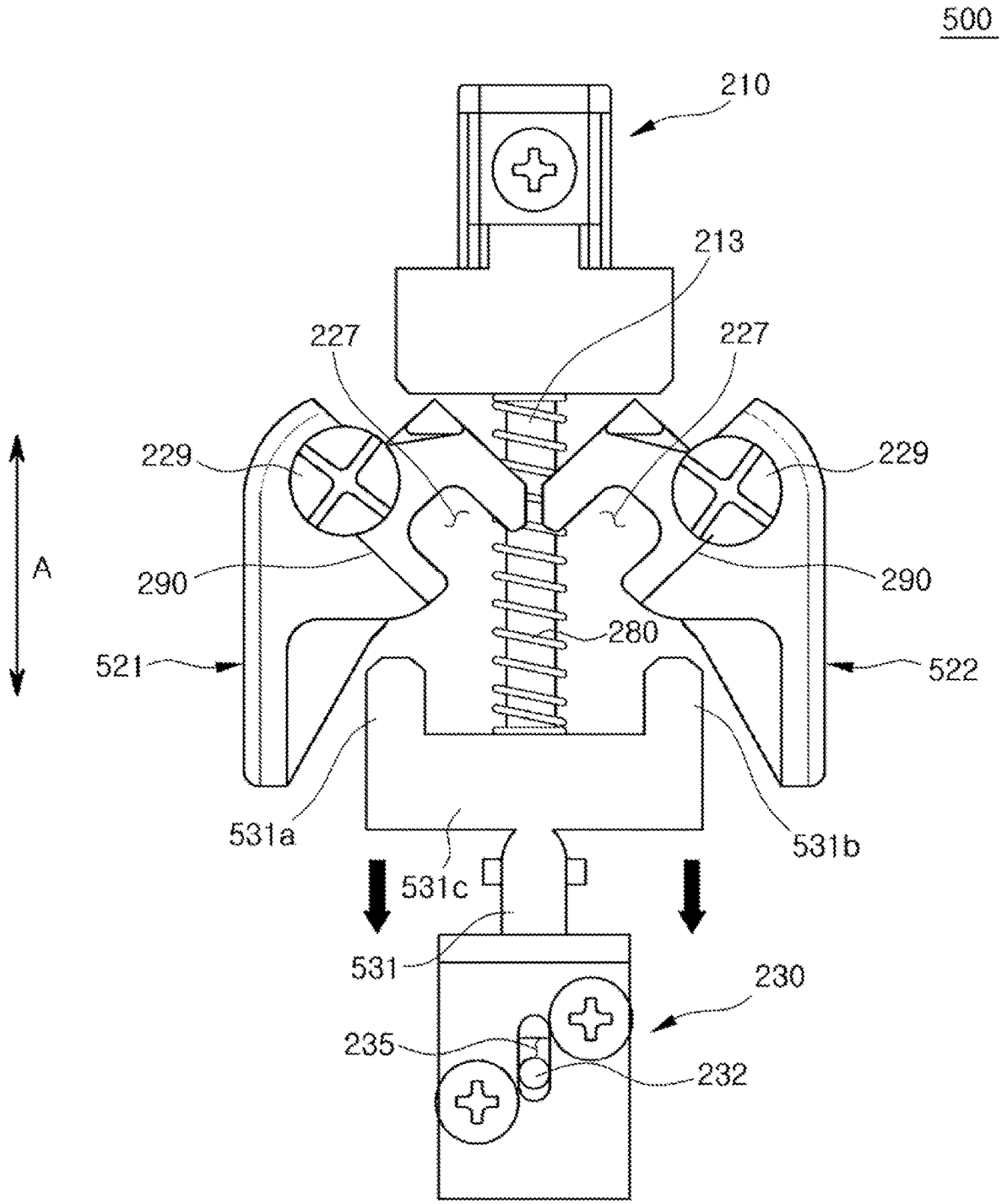
FIG. 12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MOBILE X-RAY IMAGING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of Ser. No. 15/317,401, which is the National Stage of International Application No. PCT/KR2016/010756, filed Sep. 26, 2016, which claims priority to Korean Patent Application No. 10-2015-0180778, filed Dec. 17, 2015, the disclosures of which are herein incorporated by reference in their entirety.

BACKGROUND

1. Field

The present disclosure relates to a mobile x-ray imaging apparatus, and more particularly, to a mobile x-ray imaging apparatus having an improved structure to reinforce security of an x-ray detector.

2. Description of Related Art

An x-ray imaging apparatus is an apparatus using x-rays to obtain an image of an inside of an object. An x-ray imaging apparatus may irradiate an object with x-rays and detect x-rays that have passed through the object to form an image of an inside of the object with a non-invasive method. A medical x-ray imaging apparatus may be used in diagnosing an injury, a disease, or the like that cannot be diagnosed from outside.

A typical x-ray imaging apparatus has an x-ray source and an x-ray detector fixed at a predetermined space. Consequently, a patient has to move to an examination room in which an x-ray imaging apparatus is disposed to perform x-ray imaging.

However, because it is difficult to perform x-ray imaging using a typical x-ray imaging apparatus in a case of a patient having mobility difficulties, a mobile x-ray imaging apparatus capable of performing x-ray imaging regardless of location has been developed.

Because a mobile x-ray imaging apparatus has an x-ray source mounted at a movable main body and uses a portable x-ray detector, x-ray imaging may be performed by directly going to a patient having mobility difficulties.

One or more x-ray detectors may be stored in a mobile x-ray imaging apparatus. Due to a characteristic of a mobile x-ray imaging apparatus being usable in various locations, there are concerns regarding a theft or security problem. Particularly, the one or more x-ray detectors are more vulnerable to a theft or security problem due to being portable.

SUMMARY

It is an aspect of the present disclosure is to provide a mobile x-ray imaging apparatus having an improved structure to prevent theft of an x-ray detector and reinforce security.

It is another aspect of the present disclosure to provide a mobile x-ray imaging apparatus having an improved structure to enable one or more x-ray detectors to be separately locked.

It is still another aspect of the present disclosure to provide a mobile x-ray imaging apparatus having an improved structure to enable one or more x-ray detectors to be simultaneously locked.

A mobile x-ray imaging apparatus according to a spirit of the present disclosure includes an x-ray source configured to generate and radiate x-rays, one or more x-ray detectors provided to detect the x-rays radiated from the x-ray source, a storage unit having one or more slots in which the one or more x-ray detectors are stored, and one or more locking units installed in the storage unit to limit withdrawal of the one or more x-ray detectors stored in the one or more slots, wherein the one or more locking units may include a pressing member provided to be pressable and one or more rotating members configured to directly receive a pressing force of the pressing member and provided to rotate and protrude toward an inside of the one or more slots.

The pressing member may vertically move in a first direction, and the one or more rotating members may rotate about a rotation shaft extending in a second direction.

The one or more locking units may further include a rotation limiting unit configured to limit rotation of the one or more rotating members, and the rotation limiting unit may face the pressing member and the one or more rotating members are placed therebetween.

The rotation limiting unit may include a rod configured to vertically move in the first direction, which is the same as a moving direction of the pressing member, and a solenoid coupled to the rod to adjust movement of the rod according to an electrical signal.

Each of the one or more rotating members may include a rod-corresponding surface configured to face the rod, and one end portion of the rod facing the rod-corresponding surface may move along the rod-corresponding surface when the one or more rotating members rotate.

A locking groove configured to limit rotation of the one or more rotating members by the one end portion of the rod being inserted thereinto may be formed to be recessed at the rod-corresponding surface.

The rod-corresponding surface may include a first portion disposed in front of a second portion in a direction in which the one or more rotating members rotate by being pressed by the pressing member and the second portion disposed behind the first portion in the direction in which the one or more rotating members rotate by being pressed by the pressing member, and formed above the first portion in the first direction.

A locking groove configured to limit rotation of the one or more rotating members by the one end portion of the rod being inserted thereinto may be formed to be recessed at the second portion.

The rod-corresponding surface may further include a third portion configured to connect the first portion to the second portion and be tilted toward the second portion in the first direction.

The rotation limiting unit may further include a casing configured to have the rod and the solenoid mounted therein and have a rod guide formed at one sidewall thereof, and a stopper that is formed to protrude from the rod may be configured to move vertically in the first direction and be coupled to the rod guide to limit vertical movement of the rod.

The pressing member may move along a guide pin coupled to the pressing member to guide movement of the pressing member, and a first elastic member configured to be repeatedly contracted and relaxed according to movement of the pressing member may be provided at the guide pin.

The one or more rotating members may rotate about a rotation shaft configured to pass through the one or more rotating members, and a second elastic member configured

to be repeatedly contracted and relaxed according to rotation of the one or more rotating members may be provided at the rotation shaft.

The one or more locking units may further include a connecting member configured to connect the pressing member to the rotation limiting unit and have a guide pin through-hole through which the guide pin passes formed therein.

The one or more locking units may further include a support member installed at a partition configured to divide the one or more slots, and the rotation shaft may pass through the support member and the one or more rotating members.

The second elastic member may include a torsion spring, one end portion of the second elastic member may be fixed to one sidewall of the support member, and the other end portion of the second elastic member may be fixed to a protrusion formed at one surface of each of the one or more rotating members facing the one sidewall of the support member to which the one end portion of the second elastic member is fixed.

A mobile x-ray imaging apparatus according to a spirit of the present disclosure includes a main body, an x-ray source configured to generate and radiate x-rays, one or more x-ray detectors provided to detect the x-rays radiated from the x-ray source, a storage unit provided in the main body and having one or more slots in which the one or more x-ray detectors are stored, and one or more locking units installed in the storage unit to limit withdrawal of the one or more x-ray detectors stored in the one or more slots, wherein the one or more locking units may include a pressing member provided to be pressable and configured to vertically move in a first direction, one or more rotating members provided to rotate about a rotation shaft extending in a second direction and protrude toward the one or more slots, and a rotation limiting unit including a rod vertically moving in the first direction to limit rotation of the one or more rotating members.

A pressing force of the pressing member may be directly transmitted to the one or more rotating members.

Each of the one or more rotating members may include a rod-corresponding surface configured to face the rod, and a locking groove configured to limit rotation of the one or more rotating members by one end portion of the rod facing the rod-corresponding surface being inserted thereinto may be formed to be recessed at the rod-corresponding surface.

The rotation shaft may pass through the one or more rotating members in the second direction, and, when the pressing member is pressed, the rotation shaft may be placed above the locking groove in the first direction by rotation of the one or more rotating members.

The rod-corresponding surface may include a first portion disposed in front of a second portion in a direction in which the one or more rotating members rotate by being pressed by the pressing member and the second portion disposed behind the first portion in the direction in which the one or more rotating members rotate by being pressed by the pressing member, formed above the first portion in the first direction, and having the locking groove formed to be recessed therein.

The rod-corresponding surface may further include a third portion configured to connect the first portion to the second portion and be tilted toward the second portion in the first direction.

A slope may be formed rearward in the direction in which the one or more rotating members rotate with respect to the first direction at the one surface of the rod facing the rod-corresponding surface.

The pressing member may move along a guide pin coupled to the pressing member to guide movement of the pressing member, and a first elastic member configured to be repeatedly contracted and relaxed according to movement of the pressing member may be provided at the guide pin.

The one or more rotating members may rotate about the rotation shaft configured to pass through the one or more rotating members, and a second elastic member configured to be repeatedly contracted and relaxed according to rotation of the one or more rotating members may be provided at the rotation shaft.

The second elastic member may include a torsion spring.

A third elastic member configured to be repeatedly contracted and relaxed in the first direction according to movement of the rod may be provided at the rod. The third elastic member may be relaxed when the first elastic member is contracted, and the third elastic member may be contracted when the first elastic member is relaxed.

The one or more rotating members may rotate and protrude toward an inside of the one or more slots when a pressing force is transmitted from the pressing member.

A mobile x-ray imaging apparatus according to a spirit of the present disclosure includes an x-ray source configured to generate and radiate x-rays, a plurality of x-ray detectors provided to detect the x-rays radiated from the x-ray source, a storage unit having a plurality of slots in which the plurality of x-ray detectors are stored, and a locking unit installed at the storage unit to simultaneously limit withdrawal of the plurality of x-ray detectors stored in the plurality of slots.

The plurality of slots may include a first slot and a second slot configured to abut the first slot, and a partition is placed therebetween, and the locking unit may be installed at the partition to simultaneously limit withdrawal of the plurality of x-ray detectors stored in the first slot and the second slot.

The plurality of slots may include a first slot and a second slot that are adjacent to each other, and the locking unit may include a pressing member provided to be pressable and a plurality of rotating members including a first rotating member provided to rotate and protrude toward an inside of the first slot and a second rotating member provided to rotate and protrude toward an inside of the second slot.

A pressing force of the pressing member may be directly transmitted to the plurality of rotating members.

The pressing member may simultaneously press the plurality of rotating members.

The locking unit may further include a rotation limiting unit including a rod configured to linearly move to simultaneously limit rotation of the plurality of rotating members.

Since one or more locking units are installed in a storage unit to limit withdrawal of one or more x-ray detectors stored in one or more slots, theft of the one or more x-ray detectors can be prevented while reinforcing security at the same time.

Since a plurality of locking units are installed in the storage unit, withdrawal of a plurality of x-ray detectors stored in a plurality of slots can be separately limited.

Since a single pressing member and a single rotation limiting unit are used to simultaneously adjust rotation of a plurality of rotating members, withdrawal of the plurality of x-ray detectors stored in the plurality of slots adjacent to each other can be separately limited.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects of the disclosure will become apparent and more readily appreciated from the following

description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. **1** is a view illustrating a usage example of a mobile x-ray imaging apparatus according to an embodiment of the present disclosure;

FIG. **2** is a perspective view illustrating a storage unit of the mobile x-ray imaging apparatus according to an embodiment of the present disclosure;

FIG. **3** is a perspective view illustrating the storage unit at a different angle from FIG. **2** so that an arrangement structure of a locking unit in the mobile x-ray imaging apparatus according to an embodiment of the present disclosure is visible;

FIG. **4** is a perspective view illustrating the locking unit of the mobile x-ray imaging apparatus according to an embodiment of the present disclosure;

FIG. **5** is an exploded perspective view illustrating the locking unit of the mobile x-ray imaging apparatus according to an embodiment of the present disclosure;

FIGS. **6**A to **6**C are views illustrating an operational process of the locking unit for locking a slot in the mobile x-ray imaging apparatus according to an embodiment of the present disclosure;

FIGS. **7**A and **7**B are views illustrating an operational process of the locking unit for unlocking a slot in the mobile x-ray imaging apparatus according to an embodiment of the present disclosure;

FIG. **8** is a perspective view illustrating a storage unit of the mobile x-ray imaging apparatus according to another embodiment of the present disclosure;

FIG. **9** is a perspective view illustrating a locking unit of the mobile x-ray imaging apparatus according to another embodiment of the present disclosure;

FIG. **10** is an exploded perspective view illustrating the locking unit of the mobile x-ray imaging apparatus according to another embodiment of the present disclosure;

FIG. **11** is a view illustrating the locking unit when a slot in the mobile x-ray imaging apparatus according to another embodiment of the present disclosure is locked; and

FIG. **12** is a view illustrating the locking unit when a slot in the mobile x-ray imaging apparatus according to another embodiment of the present disclosure is unlocked.

DETAILED DESCRIPTION

Hereinafter, an exemplary embodiment according to the present disclosure will be described in detail with reference to the accompanying drawings. Meanwhile, terms, such as "front end," "rear end," "upper portion," "lower portion," "upper end," and "lower end," that are used in the description below are defined on the basis of the drawings, and a shape and a position of each element is not limited by the terms.

FIG. **1** is a view illustrating a usage example of a mobile x-ray imaging apparatus according to an embodiment of the present disclosure. Hereinafter, reference numeral "**3**" refers to an object to be x-rayed. Here, the object may be a living body of a human being or an animal, but is not limited thereto. The object may be anything that may have an image of an inner structure thereof formed by a mobile x-ray imaging apparatus **1**.

As illustrated in FIG. **1**, the mobile x-ray imaging apparatus **1** may include a main body **10**. The main body **10** may be movable. A controller (not illustrated) may be provided in the main body **10**. The controller may control an x-ray source **20** to control generation of x-rays. Also, the controller may receive an electrical signal from one or more x-ray detectors **30** and generate an x-ray image.

The mobile x-ray imaging apparatus **1** may further include a hand switch **40**. The hand switch **40** may receive a command from a user and transmit the command to the controller. A command received by the hand switch **40** may include an x-ray radiation readying command or an x-ray radiating command. For example, a user may input the x-ray irradiation readying command through the hand switch **40** for capturing by the mobile x-ray imaging apparatus **1**. Also, when preparation for capturing is finished, the user may input the x-ray radiating command through the hand switch **40** so that the x-ray source **20** radiates x-rays.

The mobile x-ray imaging apparatus **1** may further include a plurality of wheels **50** configured to give mobility to the main body **10**.

The mobile x-ray imaging apparatus **1** may further include a display **60**. The display **60** may display information on a patient, an x-ray image, and the like. The display **60** may be installed at the main body **10**. The display **60** may include a touch screen function.

The mobile x-ray imaging apparatus **1** may further include a handle **70** provided at the main body **10**. A user may grip the handle **70** and push or pull the main body **10**.

The mobile x-ray imaging apparatus **1** may further include a support arm **80** and a support frame **90**. The x-ray source **20** that will be described below may be mounted on the movable main body **10** by the support arm **80**. The support arm **80** may be mounted on the support frame **90** to be rotatable in a vertical direction. The support frame **90** may be mounted at one side of the main body **10** to be rotatable in a horizontal direction. As a result, since the support arm **80** is rotatable and a tilt angle thereof may be changed, the x-ray source **20** may freely move.

The mobile x-ray imaging apparatus **1** may further include the x-ray source **20** configured to generate and radiate x-rays. As described above, the x-ray source **20** may be coupled to the support arm **80**. The x-ray source **20** receives power and generates x-rays. Energy of x-rays may be controlled by a tube voltage, and intensity and dose of x-rays may be controlled by a tube current and x-ray exposure time.

The mobile x-ray imaging apparatus **1** may further include the one or more x-ray detectors **30** provided to detect x-rays radiated from the x-ray source **20**. The one or more x-ray detectors **30** may have various sizes depending on an object of x-ray image capturing. The one or more x-ray detectors **30** may be wirelessly realized for convenience of use. The one or more x-ray detectors **30** may be stored in a storage unit **100** after capturing an x-ray image. Also, the one or more x-ray detectors **30** may be charged while being stored in the storage unit **100**.

The mobile x-ray imaging apparatus **1** may further include the storage unit **100** configured to store the one or more x-ray detectors **30**. The storage unit **100** may be provided at the main body **10**. The storage unit **100** will be described in detail below.

The mobile x-ray imaging apparatus **1** may further include one or more locking units **200** configured to limit withdrawal of the one or more x-ray detectors **30** stored in the storage unit **100**. The one or more locking units **200** will be described in detail below.

FIG. **2** is a perspective view illustrating a storage unit of the mobile x-ray imaging apparatus according to an embodiment of the present disclosure, and FIG. **3** is a perspective view illustrating the storage unit at a different angle from FIG. **2** so that an arrangement structure of a locking unit in

the mobile x-ray imaging apparatus according to an embodiment of the present disclosure is visible. In FIG. **3**, some configurations of a partition **130** are omitted so that an arrangement structure of the one or more locking units **200** is seen well.

As illustrated in FIGS. **2** and **3**, the storage unit **100** may include one or more slots **110** and **120** in which the one or more x-ray detectors **30** are stored.

Sizes of the one or more slots **110** and **120** may be different from each other. The sizes of the one or more slots **110** and **120** are determined according to sizes of the one or more x-ray detectors **30** stored in the one or more slots **110** and **120**. For example, the one or more slots **110** and **120** may include a first slot **110** configured to store an x-ray detector having a relatively small size and a second slot **120** configured to store an x-ray detector having a relatively large size.

The first slot **110** and the second slot **120** may abut each other and the partition **130** is placed there between. The partition **130** may be formed to extend from a sidewall of a storage unit body **101** configured to form an exterior of the storage unit **100** toward an inside of the storage unit **100**. The second slot **120** may be defined by the partition **130** and a frame **140**. The frame **140** may be formed to extend from the sidewall of the storage unit body **101** toward the inside of the storage unit **100** to be spaced a predetermined distance apart from the partition **130**. The frame **140** and the partition **130** may be parallel to each other.

Sizes of the one or more slots **110** and **120** are not limited to being different from each other and may be modified in various ways. For example, sizes of the one or more slots **110** and **120** may be the same. Also, the number of the one or more slots **110** and **120** is not limited to two. However, a case in which the one or more slots **110** and **120** include the first slot **110** and the second slot **120** will be mainly described as an example.

The mobile x-ray imaging apparatus **1** may further include the one or more locking units **200** installed in the storage unit **100** to limit withdrawal of the one or more x-ray detectors **30** stored in the one or more slots **110** and **120**.

The one or more locking units **200** may separately limit withdrawal of the one or more x-ray detectors **30** stored in the one or more slots **110** and **120**. Specifically, the one or more locking units **200** may include a first locking unit **200***a* configured to limit withdrawal of an x-ray detector stored in the first slot **110** and a second locking unit **200***b* configured to limit withdrawal of an x-ray detector stored in the second slot **120**.

The one or more locking units **200** may be installed in the storage unit **100**. For example, the first locking unit **200***a* may be installed in the partition **130**. Specifically, the first locking unit **200***a* may be installed in the partition **130** so that a portion thereof is exposed to the outside. The second locking unit **200***b* may be installed in the frame **140**. Specifically, the second locking unit **200***b* may be installed in the frame **140** so that a portion thereof is exposed to the outside. When described according to another aspect, the one or more locking units **200** may be installed in the storage unit **100** to be adjacent to inlets of the one or more slots **110** and **120**.

FIG. **4** is a perspective view illustrating the locking unit of the mobile x-ray imaging apparatus according to an embodiment of the present disclosure, and FIG. **5** is an exploded perspective view illustrating the locking unit of the mobile x-ray imaging apparatus according to an embodiment of the present disclosure. Hereinafter, unmarked elements refer to FIGS. **1** to **3**.

As illustrated in FIGS. **4** and **5**, the one or more locking units **200** may include a pressing member **210**. The pressing member **210** may be provided to be pressable. The pressing member **210** may vertically move in a first direction A. In other words, the pressing member **210** may linearly move in the first direction A. The pressing member **210** may move along a guide pin **213**. The guide pin **213** may extend in the first direction A to guide movement of the pressing member **210**. The guide pin **213** may be coupled to the pressing member **210**.

The one or more locking units **200** may further include one or more rotating members **220**. A pressing force of the pressing member **210** may be directly transmitted to the one or more rotating members **220**. Since elements configured to mechanically connect the pressing member **210** to the one or more rotating members **220** may be omitted when the one or more locking units **200** are designed so that the pressing force of the pressing member **210** may be directly transmitted to the one or more rotating members **220** as described above, miniaturization and structural simplification of the one or more locking units **200** may be realized.

The one or more rotating members **220** may be provided to rotate and protrude toward an inside of the one or more slots **110** and **120**. For example, a rotating member **220** of the first locking unit **200***a* may rotate and protrude toward the inside of the first slot **110**. A rotating member **220** of the second locking unit **200***b* may rotate and protrude toward the inside of the second slot **120**. The one or more rotating members **220** may rotate about a rotation shaft **229** configured to extend in a second direction B. The rotation shaft **229** may pass through the one or more rotating members **220** in the second direction B. The first direction A and the second direction B may be perpendicular to each other.

Each of the one or more rotating members **220** may include a pressing portion **221** provided to be pressed by the pressing member **210**. Each of the one or more rotating members **220** may further include a rotation limiting portion **222** provided to limit rotation of the one or more rotating members **220**. The pressing portion **221** and the rotation limiting portion **222** may have shapes that protrude toward the pressing member **210** in the first direction A. The rotation limiting portion **222** may be provided in front of the pressing portion **221** in a direction R in which the one or more rotating members **220** rotate by being pressed by the pressing member **210**. The pressing portion **221** may face a lower surface **211** of the pressing member **210** (see FIG. **6**A), and the rotation limiting portion **222** may face a front surface **212** of the pressing member **210** in the direction R in which the one or more rotating members **220** rotate by being pressed by the pressing member **210** (see FIG. **6**A).

Each of the one or more rotating members **220** may further include a rod-corresponding surface **225** configured to face a rotation limiting unit **230**. Specifically, each of the one or more rotating members **220** may further include the rod-corresponding surface **225** configured to face a rod **231**. One end portion of the rod **231** facing the rod-corresponding surface **225** may move along the rod-corresponding surface **225** when the one or more rotating members **220** rotate. A locking groove **227** configured to limit rotation of the one or more rotating members **220** by the one end portion of the rod **231** being inserted thereinto may be formed to be recessed at the rod-corresponding surface **225**.

The rod-corresponding surface **225** may include a first portion **225***a* disposed in front of a second portion **225***b* in the direction R in which the one or more rotating members **220** rotate by being pressed by the pressing member **210** (see FIG. **6**A). Also, the rod-corresponding surface **225** may

further include a second portion **225***b* disposed behind the first portion **225***a* in the direction R in which the one or more rotating members **220** rotate by being pressed by the pressing member **210** (see FIG. **6**A). The second portion **225***b* may be formed above the first portion **225***a* in the first direction A. The locking groove **227** may be formed to be recessed at the second portion **225***b*. Also, the rod-corresponding surface **225** may further include a third portion **225***c* configured to connect the first portion **225***a* to the second portion **225***b* (see FIG. **6**A). The third portion **225***c* may be tilted toward the second portion **225***b* in the first direction A on the basis of a state in which the one or more slots **110** and **120** are unlocked. A slope may be formed rearward in the direction R in which the one or more rotating members **220** rotate with respect to the first direction A at one surface **231***a* of the rod **231** facing the rod-corresponding surface **225**. Consequently, the rod **231** may smoothly pass through the third portion **225***c* while the one surface **231***a* of the rod **231** is in contact with the third portion **225***c* when the one or more rotating members **220** rotate.

The one or more rotating members **220** may also be integrally formed with the pressing member **210**.

The one or more locking units **200** may further include the rotation limiting unit **230** configured to limit the rotation of the one or more rotating members **220**. The rotation limiting unit **230** may face the pressing member **210** and the one or more rotating members **220** may be placed therebetween.

The rotation limiting unit **230** may include the rod **231**. The rod **231** may vertically move in the first direction A which is the same as a moving direction of the pressing member **210**. In other words, the rod **231** may linearly move in the first direction A which is the same as the moving direction of the pressing member **210**.

The rotation limiting unit **230** may further include a solenoid **233** coupled to the rod **231** to adjust movement of the rod **231** according to an electrical signal. The solenoid **233** may be connected via a cable **239** to a controller configured to control whether the solenoid **233** is operated. The solenoid **233** may mostly operate during a process in which the one or more slots **110** and **120** are being unlocked. That is, when a user inputs a command for unlocking the one or more slots **110** and **120**, the rod **231** moves downward in the first direction A when the solenoid **233** is operated. Accordingly, the one end portion of the rod **231** is detached from the locking groove **227**, and the one or more rotating members **220** are restored to a state of before being pressed by the pressing member **210**. Consequently, the one or more slots **110** and **120** are unlocked. A user may input a password or use a radiofrequency (RF) card to command the one or more slots **110** and **120** to be unlocked.

The rotation limiting unit **230** may further include a casing **234** configured to have the rod **231** and the solenoid **233** mounted therein. A rod guide **235** may be formed at one sidewall **234***a* of the casing **234**. The rod guide **235** may have a shape that extends in the first direction A to limit movement of the rod **231**. A stopper **232** configured to protrude from the rod **231** may be formed at the rod **231**. Movement of the rod **231** may be limited by interference between the stopper **232** and the rod guide **235**. The stopper **232** formed to protrude from the rod **231** may vertically move in the first direction A and be coupled to the rod guide **235** to limit vertical movement of the rod **231**.

The one or more locking units **200** may further include a connecting member **240** configured to connect the pressing member **210** to the rotation limiting unit **230**. Specifically, the connecting member **240** may connect the pressing member **210** to the casing **234**. A guide pin through-hole **241** through which the guide pin **213** passes may be formed at the connecting member **240**. That is, the guide pin **213** may pass through the guide pin through-hole **241** in the first direction A and may be coupled to the pressing member **210**.

The one or more locking units **200** may further include a support member **250** installed in the storage unit **100**. For example, the support member **250** of the first locking unit **200***a* may be installed in the partition **130** configured to divide the one or more slots **110** and **120**. The support member **250** of the second locking unit **200***b* may be installed at the frame **140**.

The support member **250** may include an installing portion **251** installed in the storage unit **100**. Also, the support member **250** may further include a plurality of ribs **252** extending forward in the direction R in which the one or more rotating members **220** rotate by being pressed by the pressing member **210**. A rotation shaft coupling hole **253** may be formed at the plurality of ribs **252**. The rotation shaft **229** may pass through the support member **250** and the one or more rotating members **220**. Specifically, the rotation shaft **229** may pass through the rotation shaft coupling hole **253** of the support member **250** and a rotation shaft through-hole **228** formed at each of the one or more rotating members **220**. The connecting member **240** may be fixed and coupled to the support member **250** by a fixing member **260** configured to pass through a fixing hole **254** formed at the installing portion **251**. The casing **234** may be fixed and coupled to the support member **250** by an engaging member **270** configured to pass through an engaging hole **255** formed at the plurality of ribs **252** of the support member **250**. The fixing member **260** and the engaging member **270** may include, for example, a screw.

The one or more locking units **200** may further include a first elastic member **280**. The first elastic member **280** may include a tensile spring configured to be repeatedly contracted and relaxed in the first direction A. The first elastic member **280** may be provided at the guide pin **213** and repeatedly be contracted and relaxed according to movement of the pressing member **210**. Specifically, when the pressing member **210** moves downward in the first direction A, the first elastic member **280** may be contracted. Conversely, when the pressing member **210** moves upward in the first direction A, the first elastic member **280** may be relaxed. The pressing member **210** may be restored to a state of before being pressed by a restoration force of the first elastic member **280**.

The one or more locking units **200** may further include a second elastic member **290**. The second elastic member **290** may include a torsion spring configured to be repeatedly contracted and relaxed according to rotation of the one or more rotating members **220**. The second elastic member **290** may be provided at the rotation shaft **229**. One end portion of the second elastic member **290** may be fixed to one sidewall of the support member **250**. Specifically, the one end portion of the second elastic member **290** may be inserted into a hole **256** formed at the plurality of ribs **252** and fixed. The other end portion of the second elastic member **290** may be fixed to a protrusion **221***a* formed at each of the one or more rotating members **220** or may be supported by the protrusion **221***a*. The protrusion **221***a* may be formed to protrude from the one sidewall of the support member **250** to which the one end portion of the second elastic member **290** is fixed, i.e., one surface of each of the one or more rotating members **220** facing the plurality of ribs **252** of the support member **250** to which the one end portion of the second elastic member **290** is fixed. When described according to another aspect, the protrusion **221***a*

may extend from the pressing portion **221** of each of the one or more rotating members **220** in the second direction B to face the plurality of ribs **252** of the support member **250** to which the one end portion of the second elastic member **290** is fixed. When the one or more rotating members **220** are pressed by the pressing member **210**, the second elastic member **290** may be contracted. Conversely, when the one or more rotating members **220** are not pressed by the pressing member **210**, the second elastic member **290** may be relaxed. The one or more rotating members **220** may be restored to a state of before being pressed by a restoration force of the second elastic member **290**.

The one or more locking units **200** may further include a third elastic member **300**. The third elastic member **300** may include a tensile spring configured to be repeatedly contracted and relaxed in the first direction A. The third elastic member **300** may be provided at the rod **231** and be repeatedly contracted and relaxed in the first direction A according to movement of the rod **231**. Specifically, when the one end portion of the rod **231** is inserted into the locking groove **227**, the third elastic member **300** may be relaxed. Conversely, when the one end portion of the rod **231** is detached from the locking groove **227**, the third elastic member **300** may be contracted. When described according to another aspect, the third elastic member **300** may be relaxed when the first elastic member **280** is contracted, and the second elastic member **290** may be contracted when the first elastic member **280** is relaxed.

FIGS. **6**A to **6**C are views illustrating an operational process of the locking unit for locking a slot in the mobile x-ray imaging apparatus according to an embodiment of the present disclosure. Unmarked elements refer to FIGS. **2** to **5**.

As illustrated in FIGS. **6**A to **6**C, when the pressing member **210** is pressed, the pressing force of the pressing member **210** is directly transmitted to the one or more rotating members **220**. The one or more rotating members **220** rotate and protrude toward the inside of the one or more slots **110** and **120** by the pressing force. When the one or more rotating members **220** protrude toward the inside of the one or more slots **110** and **120** as described above, withdrawal of the one or more x-ray detectors **30** stored in the one or more slots **110** and **120** may be interfered with and theft of the one or more x-ray detectors **30** may be prevented. The one end portion of the rod **231** facing the rod-corresponding surface **225** moves along the rod-corresponding surface **225** when the one or more rotating members **220** rotate, and rotation of the one or more rotating members **220** is limited when the one end portion of the rod **231** is inserted into the locking groove **227** formed at the one or more rotating members **220**. Here, the first elastic member **280** and the second elastic member **290** are contracted and the third elastic member **300** is relaxed. The rod **231** moves upward in the first direction A by a restoration force of the third elastic member **300**. The one or more slots **110** and **120** may be locked by the process described above. When the one or more slots **110** and **120** are locked, the rotation shaft **229** may be disposed above the locking groove **227** in the first direction A.

FIGS. **7**A and **7**B are views illustrating an operational process of the locking unit for unlocking a slot in the mobile x-ray imaging apparatus according to an embodiment of the present disclosure. Unmarked elements should be referred to FIGS. **2** to **5**.

As illustrated in FIGS. **7**A and **7**B, the solenoid **233** is operated when a user inputs a command for unlocking the one or more slots **110** and **120**. The rod **231** moves downward in the first direction A by the solenoid **233** being operated. The one end portion of the rod **231** is detached from the locking groove **227** when the rod **231** moves downward in the first direction A, and the one or more rotating members **220** are restored to a state of before being pressed by the pressing member **210** by the restoration force of the second elastic member **290**. Here, the first elastic member **280** and the second elastic member **290** are relaxed, and the third elastic member **300** is contracted. The one or more slots **110** and **120** may be unlocked by the process described above.

FIG. **8** is a perspective view illustrating a storage unit of a mobile x-ray imaging apparatus according to another embodiment of the present disclosure. Hereinafter, descriptions overlapping those with reference to FIGS. **1** to **7**B may be omitted. Also, like reference numerals may be given to elements having the same name as elements described with reference to FIGS. **1** to **7**B.

As illustrated in FIG. **8**, a locking unit **500** may simultaneously limit withdrawal of a plurality of x-ray detectors **30** stored in a plurality of slots **110** and **120**. That is, when the plurality of slots **110** and **120** are assumed to include a first slot **110** and a second slot **120** that abut each other and have a partition **130** placed therebetween, withdrawal of the plurality of x-ray detectors **30** stored in the first slot **110** and the second slot **120** may be simultaneously limited by the single locking unit **500**.

The locking unit **500** may be installed in the storage unit **100**. Specifically, the locking unit **500** may be installed in the partition **130** to simultaneously limit withdrawal of the plurality of x-ray detectors **30** stored in the first slot **110** and the second slot **120**.

FIG. **9** is a perspective view illustrating a locking unit of the mobile x-ray imaging apparatus according to another embodiment of the present disclosure, and FIG. **10** is an exploded perspective view illustrating the locking unit of the mobile x-ray imaging apparatus according to another embodiment of the present disclosure. Hereinafter, descriptions overlapping those with reference to FIGS. **1** to **7**B may be omitted. Also, like reference numerals may be given to elements having the same name as elements described with reference to FIGS. **1** to **7**B. A support member **250** is omitted in FIG. **9**.

As illustrated in FIGS. **9** and **10**, the locking unit **500** may include a pressing member **210** provided to be pressable. The pressing member **210** may be provided to be pressable. The pressing member **210** may vertically move in a first direction A according to a guide pin **213**.

The locking unit **500** may further include a plurality of rotating members **521** and **522**. The plurality of rotating members **521** and **522** may include a first rotating member **521** provided to rotate and protrude toward an inside of the first slot **110** and a second rotating member **522** provided to rotate and protrude toward an inside of the second slot **120**. The pressing member **210** may simultaneously press the plurality of rotating members **521** and **522**. Also, a pressing force of the pressing member **210** may be directly transmitted to the plurality of rotating members **521** and **522**. The first rotating member **521** and the second rotating member **522** may rotate about rotation shafts **229** extending in the second direction B. The rotation shaft **229** configured to pass through the first rotating member **521** and the rotation shaft **229** configured to pass through the second rotating member **522** may be parallel to each other.

The locking unit **500** may further include a rotation limiting unit **230** configured to simultaneously limit rotation of the plurality of rotating members **521** and **522**. The

rotation limiting unit **230** may face the pressing member **210** and the plurality of rotating members **521** and **522** may be placed therebetween.

The rotation limiting unit **230** may include a rod **531**. The rod **531** may vertically move in the first direction A which is the same as a moving direction of the pressing member **210**. The rod **531** may include a first locking portion **531***a* configured to limit rotation of the first rotating member **521** and a second locking portion **531***b* configured to limit rotation of the second rotating member **522**. Also, the rod **531** may further include a connecting portion **531***c* configured to connect the first locking portion **531***a* to the second locking portion **531***b* so that the first locking portion **531***a* and the second locking portion **531***b* may move as one body.

The rotation limiting unit **230** may further include a solenoid **233** coupled to the rod **531** to control movement of the rod **531** according to an electrical signal. The solenoid **233** may be connected via a cable **239** to a controller configured to control whether the solenoid **233** is operated. Because description of the solenoid **233** overlaps description thereof with reference to FIGS. **1** to **7**B, the description thereof will be omitted.

The rotation limiting unit **230** may further include a casing **234** in which the rod **531** and the solenoid **233** are mounted. Because description of the casing **234** overlaps description thereof with reference to FIGS. **1** to **7**B, the description thereof will be omitted.

As described above, the single pressing member **210** and the single rotation limiting unit **230** may be used to simultaneously control rotation of the plurality of rotating members **521** and **522**. In this way, withdrawal of the plurality of x-ray detectors **30** stored in the plurality of slots **110** and **120** may be simultaneously limited.

The plurality of rotating members **521** and **522** may be operated to be symmetrical to each other.

FIG. **11** is a view illustrating the locking unit when a slot in the mobile x-ray imaging apparatus according to another embodiment of the present disclosure is locked. Hereinafter, descriptions overlapping those with reference to FIGS. **1** to **7**B may be omitted. Also, like reference numerals may be given to elements having the same name as elements described with reference to FIGS. **1** to **7**B.

As illustrated in FIG. **11**, when the pressing member **210** is pressed, the pressing force of the pressing member **210** is simultaneously transmitted to the plurality of rotating members **521** and **522**. The plurality of rotating members **521** and **522** rotate and protrude toward the inside of the plurality of slots **110** and **120** by the pressing force of the pressing member **210**. The first locking portion **531***a* and the second locking portion **531***b* are configured to face a rod-corresponding surface **225** when the plurality of rotating members **521** and **522** rotate and respectively move along the rod-corresponding surface **225** of the first rotating member **521** and the rod-corresponding surface **225** of the second rotating member **522**, and rotation of the plurality of rotating members **521** and **522** is simultaneously limited when the first locking portion **531***a* and the second locking portion **531***b* are respectively inserted into a locking groove **227** of the first rotating member **521** and a locking groove **227** of the second rotating member **522**. Here, the first elastic member **280** and the second elastic member **290** are contracted, and the third elastic member **300** is relaxed. The rod **531** moves upward in the first direction A by the restoration force of the third elastic member **300**.

FIG. **12** is a view illustrating the locking unit when a slot in the mobile x-ray imaging apparatus according to another embodiment of the present disclosure is unlocked. Hereinafter, descriptions overlapping those with reference to FIGS. **1** to **7**B may be omitted. Also, like reference numerals may be given to elements having the same name as elements described with reference to FIGS. **1** to **7**B.

As illustrated in FIG. **12**, the solenoid **233** is operated when a user inputs a command for unlocking the plurality of slots **110** and **120**. The rod **531** moves downward in the first direction A by the solenoid **233** being operated. The first locking portion **531***a* and the second locking portion **531***b* are respectively detached from the locking groove **227** of the first rotating member **521** and the locking groove **227** of the second rotating member **522** when the rod **531** moves downward in the first direction A, and the plurality of rotating member **521** and **522** are restored to a state of before being pressed by the pressing member **210** by the restoration force of the second elastic member **290**. Here, the first elastic member **280** and the second elastic member **290** are relaxed, and the third elastic member **300** is contracted.

Although a few exemplary embodiments have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these exemplary embodiments without departing from the principles and spirit of the exemplary embodiments, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A method of releasing locking of a slot, the method comprising:

inserting an X-ray detector into a slot;

exerting a pressing force on a pressing member in a first direction in which the X-ray detector is inserted into the slot;

locking the slot as a rotary member receiving the pressing force of the pressing member is rotated in a direction (R) to protrude to an inside of the slot;

operating a solenoid of a rotation limiting unit when a lock releasing command of the slot is input;

separating a rod of the rotation limiting unit from a locking groove of the rotary member according to the operation of the solenoid;

rotating the rotary member in a direction opposite to the direction (R) to prevent the rotary member from protruding to the inside of the slot in response to the rod being separated from the locking groove; and

withdrawing the X-ray detector from the slot.

2. The method of claim **1**, wherein the pressing force of the pressing member is directly transferred to the rotary member.

3. The method of claim **1**, wherein inputting the lock releasing command of the slot includes inputting a password of a user or using a radio frequency (RF) card.

4. The method of claim **1**, wherein the separating of the rod from the locking groove includes moving the rod downward in the first direction.

5. The method of claim **1**, further comprising contracting a third elastic member provided on the rod in the first direction in response to the rod being separated from the lock groove.

6. The method of claim **5**, wherein the third elastic member includes a tensile spring that is contracted in the first direction and extended in a direction opposite to the first direction.

7. The method of claim **1**, wherein the rotary member rotates about a rotary shaft that extends in a second direction, further comprising:

rotating the rotary member as a second elastic member on the rotary shaft is extended in response to the rod being separated from the locking groove.

8. The method of claim 7, wherein the second elastic member includes a torsion spring repeating contraction and extension according to a rotation of the rotary member.

9. The method of claim 1, wherein the pressing member moves up and down directions along a guide pin extending in the first direction,

further comprising extending a first elastic member provided on the guide pin in a direction opposite to the first direction in response to the rod being separated from the locking groove.

10. The method of claim 9, wherein the first elastic member includes a tensile spring that is contracted in the first direction and extended in a direction opposite to the first direction.

11. The method of claim 1, wherein the rotary member includes a rod corresponding surface that faces the rod and has a first portion located on a front side in the direction (R) in which the rotary member is rotated, a second portion located on a rear side in the direction (R) and forming the locking groove, and a third portion connecting the first portion to the second portion,

an end portion of the rod separated from the locking groove is moved along the third portion of the rod corresponding surface according to rotation of the rotary member, to be disposed on the first portion.

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